## 7.0 EXPLORATORY STUDIES

### 7.1 Analyses of Distribution of High and Middle Ozone Days: 1986-96

In the first phase of the project, a methodology was developed to determine a set of high ozone days and a set of middle ozone days for the 1990-93 smog seasons (Blier and Winer 1996). This same general approach has now been used to define high and middle ozone days for the 1986-89 smog seasons, as well as for 1994-96. The daily-maximum hourly-average ozone concentrations on the high ozone days ranged from 28 to 35 pphm for 1986-89, from 25 to 33 pphm for 1990-93, and from 22 to 30 pphm for 1994-96. For the middle ozone days, daily-maximum hourly-average ozone concentrations were 17 pphm for 1986-89, 15 pphm for 1990-93, and 13 pphm for 1994-96.

For each of these three periods, the distribution of the high and middle ozone days through the smog season is shown (see Figures 7-1 through 7-3). Unsurprisingly, the high ozone days tended to occur mostly during the middle four months of the smog season, while the middle ozone days were generally more broadly distributed. Additionally, there appears to be a trend towards decreasing incidence of high ozone days in September and October, though further examination of the comparability of the meteorological conditions is needed. This discussion should be expanded to explain the further broad downward trend for ozone concentrations since 1995-96 and 97 (4-6 & 4-7), a noticeable shift to early season (May) peaks, and a general shift in ozone season from May through October to June through August.

The distribution by day-of-the-week of the high ozone days of 1986-89, 1990-93, and 1994-96 is shown in Table 7-1. Although previous research suggests that Saturdays tend to have higher ozone concentrations (Blier and Winer 1996), the results for the individual periods do not reveal a clear day-of-the-week pattern, perhaps because the number of days in the analysis is too small. To see if a day-of-the-week signal could be detected with a larger number of days in the calculation, the day-of-the-week distributions in Table 7-1 were summed for the high ozone days over all three periods of

analysis (fourth column, Table 7-1). The summation showed a monotonic increase in number of occurrences of high ozone days by day-of-the-week, with a minimum number of occurrences on Sundays and a maximum on Saturdays. This appears consistent with our results from Phase I of this research.

**Table 7-1.** Distribution by day of week for the high ozone days of 1986-89, 1990-93 and 1994-96.

| Day | 1986-89 | 1990-93 | 1994-96 | 1986-96 |
|---|---|---|---|---|
| Monday | 0 | 6 | 0 | 6 |
| Tuesday | 2 | 4 | 1 | 7 |
| Wednesday | 4 | 2 | 2 | 8 |
| Thursday | 2 | 3 | 7 | 12 |
| Friday | 8 | 4 | 2 | 14 |
| Saturday | 5 | 8 | 6 | 19 |
| Sunday | 3 | 1 | 0 | 4 |
| Total | 24 | 28 | 18 | 70 |

## 7.2 Analyses Using Gridded Meteorological Data

### 7.2.1 Superposed Epoch Analysis of High Ozone Days

As an exploratory analysis, we chose to use the method of Superposed Epoch Analysis (Panofsky and Brier 1958) to examine the concurrent and antecedent synoptic-scale meteorological conditions associated with the occurrence of high ozone concentrations in the Basin. This method consists of the computation of the mean of some parameter P associated with a set of event of type E which are of interest to the researcher. The mean of P is computed for equidistant time intervals leading up to, and including the time of occurrence of E in order to examine the relationship between P and E. [Mass and Albright (1989) used this technique to analyze synoptic-scale conditions associated with California Catalina Eddy events].

Accordingly, the mean 500 mb synoptic-scale field was computed at 12-hr time intervals, beginning three time intervals prior to the occurrence of the 28 high ozone days

of 1990-93, and leading up to and including the time 1700 PDT on the afternoon of the occurrence of the high ozone days (Figures 7-4 to 7-7). The mean conditions associated with high ozone days in the SoCAB were clearly associated with a strong 500 mb ridge over the western portion of the United States, with relatively light southwest winds over the SoCAB at 500 mb, while a large trough was located over the eastern Pacific. Examination of the sequence of Figures (7-4 to 7-7) indicated that the West Coast ridge axis slowly moved eastward as the time of occurrence of high ozone in the SoCAB approached.

### 7.2.2 Correlation between Gridded Constant Pressure Level Data and Daily SoCAB-Maximum Ozone

The high correlation between 850 mb temperature and high SoCAB ozone has been known for many years (Davidson et al. 1985). To further investigate the relationship between SoCAB-maximum ozone concentrations and 850 mb temperature, we correlated the set of SoCAB-maximum ozone concentrations from the smog season days of 1994-96 with the corresponding objectively-analyzed 850 mb temperatures throughout the region occurring at 1700 PDT on the afternoon of the same day. These correlations were computed using the synoptic fields occurring at a succession of 12-hour time intervals leading up to the afternoon of occurrence of the Basin-maximum ozone concentrations (Figures 7-8 to 7-11). The region of maximum correlation coefficients was located over the SoCAB. As expected, the correlation increased as the time interval between the hour of observation of the 850 mb temperature and the occurrence of the SoCAB-maximum ozone concentration (approximately 1400-1600 PDT) decreased. The highest correlation coefficient of 0.82 occurred at 33.21 °N, 116.98 °W (Figure 7-11).

The time series of the daily SoCAB-maximum hourly-average ozone concentrations was also correlated with the corresponding time series (at each grid point) of 1700 PDT 850 mb temperatures for the 1986-89 smog seasons (Figure 7-12) and the 1990-93 smog seasons (Figure 7-13). As in the analysis for 1994-96 (Figure 7-11), both

of these analyses also showed highest correlation over the region of the SoCAB. The highest correlation coefficient for 1986-89 was 0.83 and occurred at 34.28 °N, 119.04 °W, while the highest correlation coefficient for 1990-93 was 0.84 and occurred at 33.21 °N, 116.98 °W (Figure 7-14).

## 7.3 Evaluation of Industrial Emissions Data

To characterize differences in $NO_x$ emissions by day-of-the-week for stationary sources, we examined data from approximately 80 RECLAIM sources in the SoCAB (out of approximately 200 sources regulated under RECLAIM) which reported daily $NO_x$ emissions from May-September 1996. A summary of the results is given in Table 7-2.

**Table 7-2.** Summary of RECLAIM industrial emissions of $NO_x$ for 82 sites from May-September 1996.

| Day | Average (tons/d) | Std. Dev. (tons/d) |
|---|---|---|
| Sunday | 126 | 122 |
| Monday | 161 | 171 |
| Tuesday | 146 | 166 |
| Wednesday | 168 | 200 |
| Thursday | 409 | 1058 |
| Friday | 125 | 152 |
| Saturday | 128 | 158 |
| Average | 182 | 436 |

Because of the large variation in reported emissions, we excluded data for those particular days for which the standard deviation was greater than twice the mean emissions for each day of the study period. For example, Figure 7-15 shows total reported $NO_x$ emissions for each Thursday from May-September 1996.

Table 7-3 shows both the calculated average $NO_x$ emissions and corresponding standard deviations by day-of-the-week after screening of the data. Reported emissions

**Table 7-3.** RECLAIM $NO_x$ emissions (extreme reporting days excluded).

| Day | Average (tons/d) | Std. Dev (tons/d) |
|---|---|---|
| Sunday | 103 | 20 |
| Monday | 103 | 14 |
| Tuesday | 103 | 34 |
| Wednesday | 102 | 20 |
| Thursday | 101 | 20 |
| Friday | 95 | 18 |
| Saturday | 98 | 21 |
| Average | 101 | 22 |

were slightly lower on Fridays and Saturdays. However, Sunday emissions were similar to weekday emissions.

Weekday/weekend differences (post-screening) in reported RECLAIM emissions for each site are shown in Figure 7-16. To represent weekday emissions, Tuesday and Wednesday were averaged together, while Saturday and Sunday were averaged to represent weekend emissions. Figure 7-16 suggests the majority of sources have higher emissions on weekdays than on weekends, with just three sites (No. 4, 18, and 21) exhibiting significantly higher overall emissions on weekend days. These three sites are all electric power generating facilities (SIC code = 4911). Note the differences in Figure 7-16 are small (pounds) compared with the mean in tons per day.

In general, these data were of limited use in meeting the objectives of this study because no significant day-of-the week differences were found (Table 7-3).

## 7.4 Investigation of Traffic Activity Patterns

We were interested in whether relationships could be established between 0600-0900 PDT ambient CO concentration and traffic count data, as expected from the fact that mobile sources are the only significant source of CO. Also, according to Fujita (1994), the early morning period reflects emissions primarily from on-road vehicles with minimal carryover of aged emissions at surface air monitoring stations. Towards this objective,

we explored the possible utility of a comparison (on a relative basis) between ambient CO concentrations from various SCAQMD air monitoring stations and traffic count data taken from the nearest Caltrans traffic control sites.

We were also interested in determining the degree to which traffic count data could serve as an indicator of day-of-the-week differences in the mobile source emission inventory.

To investigate whether vehicle use patterns can account for differences in SoCAB air quality between weekdays and weekend days, we performed a preliminary analysis of the Caltrans 1994-95 traffic count data for Los Angeles County. Preliminary results (from a total of 36 conventional traffic control sites) suggest a consistent day-of-the-week pattern throughout the SoCAB, with the largest traffic volume occurring on Fridays. There was also a slight upward trend in daily traffic volumes as the week progressed from Monday to Friday. In general, there was a significant decrease in traffic volume on Saturday and an even larger decrease on Sunday.

## 7.5 Analysis of Carbon Monoxide Trends by Day-of-the-Week: 1986-96

To elucidate day-of-the-week differences in mobile source activity and because of the paucity of hydrocarbon data, we investigated 0600-0900 PDT carbon monoxide (CO) concentrations at all air monitoring stations (N=14) in Los Angeles county (except Lancaster) for May-September 1986-96 (Figure 7-17). Despite an increase in vehicle miles traveled (VMT) over the eleven-year study period, 0600-0900 PDT ambient CO concentrations have decreased slightly during this period. Data completeness for all years inspected averaged over 98%. The detection limit of the continuous CO monitors used at the monitoring sites (NDIR, Bendix 8501) is 0.5 ppm, and CO data are reported to the nearest whole integer.

We examined differences in weekday/weekend 0600-0900 PDT CO trends over the eleven-year study period for the same Los Angeles county air monitoring sites (Figure 7-18). Whereas weekday (Monday through Friday average) ambient CO during the

morning hours has decreased steadily, weekend (Saturday/Sunday average) ambient CO does not show a similar trend over the eleven-year period. Interestingly, both weekday and weekend 0600-0900 PDT ambient CO concentrations appear to cycle by year which is consistent with results found by Fujita (1994) in evaluating ambient CO for the June through August period for the years 1987-93.

We next examined the growing contribution of weekend ambient CO to the seven-day weekly average for all 21 SoCAB sites which monitor CO. Here, the daily mean concentrations were normalized to the weekly average. Figure 7-19 shows the normalized CO contribution from each day-of-the-week to the average weekly concentration for each year. Saturday 0600-0900 PDT average ambient CO has increased relative to the weekly 0600-0900 PDT average CO concentration from approximately 80% to greater than 90% of the weekly average for the eleven-year period studied.